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EXPLOSIONS IN ILLINOIS COAL MINES

1883 TO 1932

BY

C. A. Herbert

From 1901 to January 1, 1933, inclusive, the only years free from explosions were 1906, 1912, and 1925; in each of these years, however, men were killed either by gas ignitions or blown-out shots of black blasting powder.

Table 1 summarizes the data available on explosions in Illinois from 1883 to 1932, in which marked violence occurred. Under the heading "Other Cases" are listed the number of gas ignitions in which men were killed and the number of men killed each year from this cause, as well as the number of minor explosions due to blown-out shots of black blasting powder and the number of men killed each year from this cause.

Fifty-seven explosions of limited or considerable extent, for which more or less complete data are available, killed a total of 497 men and injured 151; 72 gas ignitions killed 88 men; 151 minor explosions due to blown-out shots of black blasting powder killed 179 men - a total of 764 fatalities from 1883 to 1932, inclusive, or an average of about 15 per year.

The number killed in the cases listed, for which some data are given, ranged from 1 to 54 with an average of about 9 per explosion.

Fatality Rates

Table 2 presents the fatality rates for gas and dust explosions per million tons of coal produced and per million man-hours of surface and underground work.

From 1883 to 1900 most of the coal was produced from the comparatively nongassy beds of the northern and central part of the State; and although black blasting powder was used almost entirely as an explosive, it was not employed with the utter disregard for safety that later marked its use in the solid shooting mines of the section. This fact is reflected in the low fatality rates from explosions during this period.

Development of the deeper, more gassy seams of southern Illinois began about 1901; the era of reckless shooting with black blasting powder in solid shooting mines also began about this time and no doubt accounts for the increased fatality rates from explosions after that date.

The years 1929, 1930, and 1931 show very marked improvement in the fatality rates from mine explosions. The record for 1932, however, was the worst in loss of life from explosions in the history of the industry in Illinois, due to a serious disaster in December of that year.

Causes of Explosions in Illinois

Table 3 summarizes the causes of the 57 explosions listed in table 1. It will be observed that open lights caused 27, or 47.5 percent, of the explosions; blown-out shots of black blasting powder caused 12, or 21 percent; mine fires 6, or 10.5 percent; electricity 5, or 8.8 percent; explosives 4, or 7 percent; striking matches 3, or 5.2 percent.

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TABLE 1. - Gas and dust explosions in bituminous mines of Illinois, 1883-1932

							Explosion							Other Cases							
Case No.	Date	County	Type of mine	Tons per day	Average employed	Men in mine	Type	Extent	Limited by	Cause of accumulation	Source of ignition	Other factors	Possible means of prevention at time	Killed	Injured	Escaped uninjured	Gas ignitions	Killed	Blown-out shots black blasting powder	Killed	Total yearly fatalities
1	1883 Jan. 6	Randolph	Shaft, nongasey	150	40	40	Gas	-	-	Lack of ventilation (?)	Open lights (?)	-	-	10	-	30	-	-	-	-	10
	1884* 1/	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	3	-	-	3
	1885*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1886*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	1
	1887*)																				-
	1888*)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1889*)																				-
	1890*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	2	-	-	2
	1891*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	4	-	-	4
	1892*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	2	-	-	2
	1893*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	1
	1894*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	2	-	-	2
	1895*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1896*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	1
2	1897	Williamson	do	250	50	6	Gas	Limited	Amount of gas	Lack of ventilation	Open lights	No examination. Fire boss sick	Examine mine before shift	4	2	-	-	-	-	-	4
	1898*)																				-
	1899*)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1900*)																				-
3	1901	St. Clair	Shaft, nongassy	200	26	17	Dust	Wide-spread	Size	-	Blown-out shot, black blasting powder	Solid shooting, overcharged and poorly placed shots	Undercutting, better supervision	3	6	8	1	1	-	-	4
4	1902: Oct.13	Sangamon	do	500	110	110	do	Limited	Expansion, incomb.	-	do	do	do	3	-	107	-	-	-	-	3
5	1903: Mar.13	Livingston	do	1,000	263	15	Gas	do	Amount of gas	Sealing fire	Fire	-	-	3	-	12	-	-	2	5	-
6	Mar.15	do	do	1,000	263	6	do	Violent	do	do	do	2d explosion 2 days after 1st		5	-	1	-	-	-	-	-
7	Mar.16	do	do	1,000	263	-	do	Extremely violent	-	-	do	3d explosion 3d day, topman killed		1	-	-	-	-	-	-	-
8	Mar.23	Menard	do	400	80	80	Dust	Limited	Expansion	-	Blown-out shot, black blasting powder	Solid shooting, overcharged poorly placed shots	Undercutting, better supervision	6	-	74	-	-	-	-	-
9	Mar.31	Marion	do	600	137	137	do	do	do	-	do	do	do	8	3	126	-	-	-	-	28
10	1904: May 11	Williamson	do	1,600	360	267	Powder and dust	do	do	-	Explosives	Car black blasting powder ignited by elec. current	Insulated car, delivering explosives when current is off	10	12	245	-	-	2	3	-
11	Dec. 9	Saline	Gassy	90	26	26	Dust	do	do	-	Blown-out shot, black blasting powder		Better supervision, undercutting coal	4	-	22	-	-	-	-	17
12	1905: Apr. 3	Franklin	do	438	101	101	Gas and dust	Wide-spread	-	Improper ventilation, fan down 55 hrs.	Open lights	No examination before men entered	Closed lights, better ventilation and supervision	50	-	51	-	-	-	-	-
			do	-	-	-	-	-	-	-	-			-	-	-	-	-	1	1	51
	1906*	-	-	-	-	-	-	-	-	-	-			-	-	-	2	3	5	9	12
13	1907: Sept.7	Franklin	Gassy	1,200	200	200	Gas	Limited	Lack of gas	Sealing old workings	Open lights		Closed lights, better ventilation, supervision and inspection	4	18	178	1	1	3	11	16
	1908*	-	-	-	-	-	-	-	-	-	-			-	-	-	2	2	12	28	30
14	1909: Jan.10	Franklin	Gassy	2,500	375	27	Gas	Limited	Lack of gas	Sealed because of fire	Mine fire	Seals removed too soon	Leaving seals in longer	26	-	1	3	3	9	17	-
15	Feb. 9	do	do	2,500	375	16	do	Wide-spread	do	Sealing shafts, stopping ventilation to smother fire	do	do	do	3	-	16	-	-	-	-	-
16	Feb.16	do	do	1,000	125	4	Dust	do	Expansion	None	Blown-out shot, black blasting powder	Solid shooting	Closer supervision, proper placing of holes, incombustible stemming, undercutting, snubbing	4	-	-	-	-	-	-	-
17	Dec.23	Williamson	Nongassy	2,000	350	350	Gas	Limited	Lack of gas	Lack of ventilation	Open lights	Interrupted ventilation	Supervision, examination 2 hrs. before men enter mine	8	2	340	-	-	-	-	61
18	1910: Nov.11	Montgomery	do	2,000	403	403	do	do	do	do	do	Gas in old works	Fencing off section known to contain gas	6	11	386	2	2	1	1	9
19	1911: Oct.23	Saline	Gassy	2,200	375	375	Gas and dust	do	Amt. of gas inert material	do	do	Gas in idle mine connecting, while repairing shaft	Closer supervision and inspection	8	8	359	1	1	1	1	10
	1912*	-	-	-	-	-	-	-	-	-				-	-	-	2	2	-	-	2
20	1913: Feb.19	Saline	Gassy	1,500	250	250	Gas	Limited	Amt. of gas	Lack of ventilation	Open lights		Closer supervision and inspection	4	-	246	2	3	3	6	13

1/ Years marked with an asterisk are those in which there were no major accidents, or in which no accidents occurred.

TABLE 1. - Gas and dust explosions in bituminous mines of Illinois, 1883-1932--Continued

Case No.	Date	County	Type of mine	Tons per day	Average employed	Men in mine	Explosion										Other cases				
							Type	Extent	Limited by	Cause of accumulation	Source of ignition	Other factors	Possible means prevention at time	Killed	Injured	Escaped uninjured	Gas ignitions	Killed	Blown-out shots black blasting powder	Killed	Total yearly fatalities
21	1914: Aug. 23	Franklin	Shaft, gassy	1,500	300	300	Gas	Limited	Amount of gas	Lack of ventilation	Open lights	Failure to test for gas in new rooms	Closed lights, closer supervision and inspection	2	-	298	2	2	-	-	-
22	Oct. 1	Perry	Shaft, nongassy	1,500	312	1	Dust	Wide-spread	-	-	Black powder	Explosives being delivered on entry	Closed lights, permissible explosives, insulated car	1	-	-	-	-	-	-	-
23	Oct. 14	Franklin	Shaft, gassy	2,600	357	357	Gas and dust	do	Expansion	Deranged ventilation	Open lights	Gas reported, stopping being repaired	Better ventilation, inspection not more than 3 hours before starting time. Closed lights.	52	19	226	-	-	-	-	57
24	1915: Apr. 5	Montgomery	Shaft, nongassy	2,300	600	300	do	Limited	Inert material	Inadequate ventilation	do	Occurred as men reached face of entry	do	11	-	289	-	-	6	9	-
25	July 27	Franklin	Shaft, gassy	2,673	416	416	do	do	Expansion	do	do	Occurred Monday morning, last examination Saturday night	Closer examination for gas, closed lights, rock-dusting	9	8	399	-	-	-	-	29
26	1916: Mar. 16	Perry	Shaft, nongassy	2,000	300	300	Dust	do	-	-	Ignition of keg of powder	None	Permissible explosives	2	1	297	5	5	3	3	-
27	July 30	Christian	do	1,060	316	6	Gas	Extensive	Amount of gas	Fan shut down	Open lights	Mine not examined before men entered	Closer examination, running fan longer, closed lights	4	2	-	-	-	-	-	-
28	Dec. 13	Franklin	Shaft, gassy	1,000	240	240	do	Limited	do	Cave-in, lack of ventilation	do	None	Closed lights, more careful inspection	1	7	232	-	-	-	-	15
29	1917: Feb. 23	Sangamon	Shaft, nongassy	1,000	201	4	Dust	Fairly extensive	Expansion, incombustible	Blown-out shot	Blown-out shot	Solid shooting, overcharged shots	Permissible explosives, undercutting	4	-	-	3	4	4	5	-
30	Mar. 12	Saline	Shaft, gassy	1,150	180	9	Gas and dust	Limited	Expansion, inert material	Door left open	Open lights	Fire boss using open lights	Closed lights	4	-	5	-	-	-	-	-
31	June 3	Williamson	Shaft, nongassy	3,000	394	20	Gas	do	Amount of gas, moisture	Removal of curtain	do	Gas accumulated in old workings	Closed lights, better supervision and inspection	9	2	9	-	-	-	-	-
32	July 26	Franklin	Shaft, gassy	1,500	275	275	Gas and dust	do	Amount of gas	Squeeze, lack of ventilation	Trolley locomotive	Gas accumulated in worked-out territory, pushed out by fall	Better supervision and inspection	1	1	273	-	-	-	-	-
33	Nov. 29	do	do	3,500	423	17	do	Wide-spread	-	Door left open	Open lights	No examination	Closed lights, rock-dusting, better examination, supervision	17	-	-	-	-	-	-	-
34	Dec. 5	do	do	4,000	700	19	do	Limited	do	Sealing mine mine fire	Open lights and fire	4 explosions	Closed lights	3	13	3	-	-	-	-	47
35	1918: Feb. 22	Macoupin	Shaft, nongassy	2,200	475	475	Dust and powder	do	Inert material, expansion	None	Explosives	Explosion of 26 kegs black blasting powder, ignition by electricity	Deliver powder at night with electricity off	4	-	471	-	-	-	-	-
36	Feb. 23	Sangamon		1,000	163	4	Dust	Wide-spread	-	-	Blown-out shot, black blasting powder	-	-	4	-	-	5	8	3	3	-
37	Aug. 14	Saline	Shaft, gassy	850	200	200	Gas and dust	Limited	Amount of gas incombustible	Lack of ventilation	Open lights	-		2	-	198	-	-	-	-	-
38	Sept. 28	Franklin	do	3,100	500	34	do	do	Amount of gas, moisture	Sealing mine fire	do	Gas ignition outby seals	Closed lights	21	-	13	-	-	-	-	42
39	1919: Jan. 6	do	Shaft	3,435	500	500	Gas	do	Rock-dust	Cut through into old works	do	Mine manager failed to carry out instructions of State inspector	-	3	1	496	-	-	3	5	-
40	May 12	Marion	Shaft, nongassy	1,400	518	4	Dust	-	-	-	Blown-out shot.	-	Better supervision permissible explosives	4	-	-	-	-	-	-	12
41	1920: Nov. 11	Williamson	do	550	118	2	do	Limited	Size of mine	None	Blown-out shot, black blasting powder	None	Undercutting, permissible explosives	2	-	-	2	2	5	6	-
42	Jan. 29	do	do	2,000	350	4	do	do	-	None	do	-		1	-	3	-	-	-	-	11
43	1921: Jan. 14	Franklin	Shaft, gassy	4,000	400	41	Gas and dust	do	Rock-dust, expansion	Squeeze in old workings	Lighted match from smoking	Squeezing forced gas onto haulage	Closer inspection and supervision	2	7	-	4	4	1	2	-
44	Feb. 14	Saline	do	1,240	254	254	Gas	do	Amount of gas, inert material	Lack of ventilation	Open lights	-	Closer supervision, closed lights, ventilation	3	-	251	-	-	-	-	-
45	Feb. 23	Marion	Shaft, nongassy	3,000	450	3	Dust	do	Expansion, inert material	-	Blown-out shot, black blasting powder	Solid shooting, badly placed, overcharged shots	Undercutting, permissible explosives	3	-	2	-	-	-	-	-
46	Aug. 31	Saline	Shaft, gassy	3,000	500	500	Gas	do	Amount of gas	Poor ventilation	Open lights	Gas in entries not working, hole drilled into, gas lighted at hole	Closer inspection and supervision, closed lights	11	-	489	-	-	-	-	25

TABLE 1. - Gas and dust explosions in bituminous mines of Illinois, 1883-1932--Concluded

Case No.	Date	County	Type of mine	Tons per day	Average employed	Men in mine	Explosion										Other cases				
							Type	Extent	Limited by	Cause of accumulation	Source of ignition	Other factors	Possible means prevention at time	Killed	Injured	Escaped uninjured	Gas ignitions	Killed	Blown-out shots black blasting powder	Killed	Total yearly fatalities
47	1922: Sept. 29	Williamson	Shaft, nongassy	2,500	385	385	Gas	Limited	Amount of gas,	Lack of ventilation	Open lights	Entries not working, not examined	Closer inspection and supervision, closed lights, and sealing of unventilated sections	5	-	-	3	3	7	10	18
48	1923: Dec. 26	Franklin	Shaft, gassy	6,000	850	850	do	do	Amount of gas, expansion	do	do	Gas accumulated in pillar work	Closed lights, better inspection and supervision	2	14	874	10	13	9	10	25
49	1924: Jan. 25	Williamson	do	3,000	400	370	Gas and dust	do	Expansion and non-incombustible	Squeeze in worked out section	do	Recovery of material in worked-out section	Closer supervision and inspection, rock-dust, lights	33	7	330	-	-	10	14	47
	1925*		-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	5	-	-	5
50	1926: Jan. 29	Franklin	Shaft, gassy	10,000	1,200	1,137	Gas and dust	Limited	Moisture, rock-dust	Lack of ventilation	Striking match	Fire boss lighted safety lamp	Permissible flame safety lamp, rock-dusting, better ventilation	5	-	1,132	2	2	10	13	20
51	1927: Mar. 30	Saline	do	1,500	216	196	do	do	Moisture, incombustible in dusts	do	Open lights	Moving body of gas, men in mine	Better ventilation, closed lights, permissible machinery, rock-dusting, better supervision	8	3	185	2	2	6	6	-
52	Dec. 20	Williamson	Shaft, nongassy	3,400	450	30	Gas	do	do	do	Electricity	Fire boss rode to face on haulage locomotive	Not allow fire boss to ride locomotive to face, examine mine before shift	7	-	23	-	-	-	-	23
53	1928: Jan. 9	Franklin	Shaft, gassy	4,200	750	652	Gas and dust	do	Expansion, incombustible in dusts	do	Striking match, smoking	Closed-light mine, examined too long before shift started	Examination not over 2 hours before shift. Search for matches, rock-dusting	21	-	631	2	2	4	5	28
54	1929: Dec. 1	do	do	4,500	600	24	do	do	Expansion, rock-dust	Caving of abandoned workings	Electricity	Inadequate inspection of old works close to open equipment	Permissible equipment, better ventilation, inspection, and supervision	7	-	17	-	-	2	3	10
55	1930: Mar. 18	do	do	6,000	300	300	do	do	do	Door left open	do	Open-type equipment closed lights	Permissible equipment, examine for gas by machine men	3	3	294	-	-	-	-	3
56	1931: May 28	Jackson	do	4,900	470	83	Dust	do	Rock-dust	-	do	Dust cloud caused by wrecked trip	Rock-dusting, permissible equipment, recess legs of timber sets in ribs	2	1	80	1	1	1	2	5
57	1932: Dec. 24	Shelby	Shaft, nongassy	400	104	57	Gas and dust	Extensive	Amount of gas and incombustible in road dusts	Poorly built seals to old workings and sudden drop of barometer, poor ventilation	Open lights		Better ventilation, better sealing of old "works", closed lights	54	-	2	1	1	1	1	56
				123,086	19,739	10,799								497	151	9,744	72	88	115	179	764

1/ Years marked with an asterisk are those in which there were no major accidents, or in which no accidents occurred.

Table 2.- Gas and Dust Explosion Fatalities in Illinois Coal Mines, 1883 to 1932, Inclusive.

Years	Fatalities per million		Percentage of explosion fatalities to total fatalities.
	Tons	Man-hours	
1883-1890	0.17	0.04	2.0
1891-1895	.10	.02	2.7
1896-1900	.04	.02	1.3
1901-05	.62	.23	14.5
1906-10	.42	.17	8.7
1911-15	.38	.19	13.0
1916-20	.33	.18	12.4
1921-25	.30	.22	13.2
1926	.26	.19	12.1
1927	.50	.32	21.7
1928	.50	.34	20.1
1929	.16	.12	9.2
1930	.06	.04	2.7
1931	.11	.09	5.5
1932	1.64	1.48	49.1

TABLE 3.- Causes of Explosions

Causes	Number of explosions	Percent
Open lights	27	47.5
Blown-out shots of black blasting powder	12	21.0
Mine fires	6	10.5
Electricity	5	8.8
Explosives	4	7.0
Striking matches	3	5.2
Total	57	100.0

Open lights.- Although open lights were responsible for 47.5 percent of the explosions in Illinois, during the 7-year period 1926 to 1932, inclusive, there were 8 explosions, and only 1 is attributed to open lights. It would therefore appear that general adoption of electric cap lamps in the gassy mines of the southern field has materially reduced the number of explosions from this cause.

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Blown-out shots of black blasting powder.- Reckless use of black blasting powder, including pellet powder, caused 12 explosions of more or less violence and extent, in which 48 men were killed. In addition, 115 minor explosions from blown-out shots, caused 179 fatalities; thus 227 miners, mostly shot firers, lost their lives as a result of the use of black blasting powder to "bring down" coal in Illinois mines.

Mine fires.- Six explosions occurred as a result of mine fires, 3 at 1 mine alone. At this particular mine 3 men were killed in the first explosion, 5 in the second (which took place 2 days after the first), and 1 man on top in the third (which occurred on the fourth day after the first). The first 2 explosions occurred during attempts to seal the fire underground.

In one instance, during the sealing of a fire 21 men were killed by the ignition of gas in the return from the fire by an open light some distance outby, where the seals were being built.

Electricity.- Five explosions were due to electricity; the first one occurred in 1917 and the others in 1927, 1929, 1930, and 1931. This emphasizes the increased explosion hazard that has been introduced into the mines of this State by the very marked increase in the use of electrically operated mine equipment in the gassy and dusty mines of southern Illinois in recent years and points clearly to the desirability of increased precautions against gas accumulations through sluggish or interrupted ventilation, as well as to the need for use of permissible mine equipment.

Explosives.- Four explosions were initiated by accidental ignition of black blasting powder. However, none of these took place in recent years, indicating that greater care is now being used in handling and transporting black blasting powder than formerly, and also that the increased use of permissible explosives has reduced this hazard materially.

Striking matches.- Striking matches in closed-light mines caused three explosions; in two instances men attempted to smoke and in the third a brattice man tried to light his flame safety lamp while in an explosive mixture of gas. These explosions indicate the desirability of rules against carrying matches and smoking materials into closed-light mines and strict enforcement of such rules by searching the employees at intervals.

The explosion caused by attempting to relight a flame safety lamp with a match shows the necessity for using only permissible flame safety lamps, which may be unlocked only with a suitable magnet and which are equipped with igniters for lighting, making it unnecessary to take them apart to light them with a match should the flame be accidentally extinguished.

Types of Explosions in Illinois Mines

Table 4 classifies, in accordance with available data, the mines in which explosions occurred as gassy and "nongassy" and shows the number and types of explosions that occurred under each classification.

TABLE 4.- Types of Explosions in Illinois Mines

Condition	Gas	Dust	Gas and dust	Total
"Nongassy"	11	14	2	27
Gassy	10	2	18	30
Explosions	21	16	20	57
Fatalities	118	67	312	497

CAUSES OF GAS ACCUMULATIONS AND DUST SUSPENSIONS IN ILLINOIS COAL MINES

In 41 of the 57 explosions gas ignitions were the primary cause; in the remaining 16, so far as is known, gas apparently played no appreciable part. Of the 16 explosions in which gas is thought to have played no part 12 were due to blown-out shots of black blasting powder in solid shooting mines. One was due to the ignition by an electric arc from the trolley wire of a cloud of coal dust caused by a wrecked trip; in this mine a dip or "swag" in the haulage entry caused the car couplings in the trip alternately to slacken and tighten, resulting in bumping of cars with considerable coal spillage at this point; the coal was ground up under the car wheels, causing a large amount of dust; it was at this point that the wreck occurred, knocking out several sets of timbers. It is noteworthy, however, that the entry was well rock-dusted on either side of this swag, and the explosion was stopped in both directions by the rock-dust.

PREVENTION OF EXPLOSIONS IN ILLINOIS MINES

In the reports of the various explosions occurring in Illinois recommendations were made, which it was believed, would prevent a recurrence. These recommendations and the number of times they were made are given in table 6.

Inspection.- Inspection for gas 6 or more hours before the working shift entered the mine, with the possibility of gas accumulations between the time of inspection and the time the shift entered the mine, has been responsible for a number of explosions. Inadequate inspection, or failure to inspect old workings before permitting men to enter them with open lights, has also caused several explosions. Recommendations for better inspection for gas, both before and during the shift, were made 21 times.

One explosion in which 4 men were killed was due to an open light; the fire boss, who carried the open light in addition to a flame safety lamp, encountered a larger body of gas than he expected and ignited it with his open light. This practice is not at all uncommon in mines considered only slightly gassy but is always dangerous, as records show that not fewer than 12 fire bosses and 5 mine foremen have been killed in Illinois mines from this cause, in addition to the case cited above.

TABLE 5.- Causes of Gas Accumulations and Dust Suspensions in Illinois Mines

Causes	Number of explosions
Insufficient or interrupted ventilation	22
Insufficient ventilation at face	10
Insufficient ventilation, other than at face	9
Interrupted ventilation	1
Raised curtain	1
Repairing stopping	1
Open doors	3
Door left open	3
Fans	3
Fans not operating	3
Falls of roof or coal	5
Falls of roof released gas	1
Pillar removal	2
Fall of roof pushed gas out of abandoned workings	2
Feeders and inrush of gas	1
Inrush of gas from idle adjoining mine	1
Miscellaneous	7
Removing fire seals before fire extinguished	2
Sealing mine fires	5
Dust raised into suspension	16
Shooting off solid	12
Trip of cars wrecked	1
Ignition of black blasting powder	3
Total	57

TABLE 6.- Recommendations for preventing explosions at the time of occurrence

Recommendations	Times recommended
Better inspection	21
Better supervision	20
Undercutting coal	19
Closed lights	16
Dust control	15
Better ventilation	14
Permissible explosives	13
Incombustible stemming	8
Permissible equipment	7
Taking explosives into mine when electricity is cut off	3
No smoking	3
Better placement of shots	2
Leave fire sealed until extinguished	2
Proper sealing of old workings	2
Sealing mine on top	1
Snubbing of coal	1
Remove machine cuttings before shooting	1
Inspection idle workings	1
Fire boss not to carry open light	1
Reversal of air currents	1
Permissible flame safety lamps	1
Not move gas when men are in mine	1
Fencing old workings known or suspected of containing gas	1

Supervision.- Recommendations for better supervision in connection with ventilation, handling of explosives, shooting, and rock-dusting appear 20 times and undoubtedly could or should have been made in many additional instances.

Undercutting coal.- Recommendations for undercutting the coal and discontinuing solid shooting appear 19 times. When the number of fatalities (225) from explosions due to solid shooting is considered the importance of this recommendation is apparent.

Dust control (rock-dusting, sprinkling, and water on cutter bar).- The control of the dust hazard by rock-dusting and watering was recommended 15 times. The efficacy of rock-dusting has been recognized for a number of years, but there has evidently been a general lack of knowledge of the amount of rock-dust and the surfaces on which it should be placed necessary to prevent the propagation of a coal-dust explosion. Since most explosions start in the active working sections of a mine it is absolutely necessary that first consideration be given to these sections rather than to rock-dusting the haulage roads only, as is usually done. The rock-dust should be applied to all open workings, including rooms, entries, and air courses, as well as to the haulage roads. Open and abandoned sections of the mine in which it is impossible to use a rock-dust distributor should be protected by suitable rock-dust barriers.

To control the dust hazard effectively, in addition to rock-dusting the formation of dust should be prevented at its source, namely the face, by the application of water sprays to the mining-machine cutter bars, by wetting down broken coal after shooting, and by sprinkling the roof, ribs, and floor approximately 50 feet back from the face before shooting.

Closed lights.- Recommendations for closed lights appear 16 times in the more recent reports, as it is only within recent years that a satisfactory portable electric cap lamp has been available. Most gassy mines of southern Illinois are now using this type of lamp, a practice that unquestionably has aided materially in the avoidance of explosions in those mines.

Ventilation.- Recommendations for better ventilation appear 14 times; ventilation is perhaps the most important phase of operation of coal mines from an explosion-prevention standpoint. Ventilating fans at most mines are adequate; the greatest drawbacks to proper ventilation at the face workings usually are inadequate air courses and leaky doors and stoppings. The air courses become so choked by falls that it is impossible to pass the desired quantity of air through them, while it is not uncommon for as much as 80 per cent of the air being delivered by the fan to leak from the intake to the return long before the face workings are reached.

Permissible explosives.- Recommendations for the use of permissible explosives appear 13 times; there is no doubt that the increased use of this explosive in preference to black blasting powder has been an important factor in reducing the number of explosions in later years.

Incombustible stemming.- It is relatively common practice to use fine coal dust for tamping shots, although coal-dust stemming increases many times the flame given off by a shot. An explosive that would not ignite gas or dust if incombustible stemming were used may do so if coal dust is used. Recommendations for the use of incombustible stemming were made 8 times.

TYPES OF EXPLOSIVES USED

Table 7 shows the amount of black blasting powder and permissible explosives used in Illinois for 1915, 1919, 1924, 1929, and 1932. The very marked decrease in the use of black blasting powder and the increase in permissibles is apparent.

TABLE 7.- Amount of explosives used, 1915-32, pounds

Year	Black blasting powder	Permissible explosives
1915	27,683,150	1,342,334
1919	40,050,200	2,461,331
1924	39,746,475	3,299,727
1929	10,356,625	3,910,677
1932	5,904,372	1,538,286

From information in the annual reports of the Illinois Department of Mines and Minerals.

Permissible equipment.- The use of electrical equipment underground introduces numerous sources of gas and dust ignitions. Bureau of Mines Circular 6540 shows that during the 4 years ended June 30, 1931, 45.8 percent of all mine explosions were of electrical origin and that such explosions accounted for 74.8 percent of all explosion fatalities; during this period in Illinois 3 of the 4 explosions were due to the ignition of gas or dust by electric sparks or arcs.

Recommendations suggesting the use of permissible electrical equipment were made 7 times. In this connection, however, it is recognized that with the depressed condition that has obtained in the coal industry for a number of years it would be financially impossible to replace the present equipment with permissible equipment; however, it would appear to be possible to make it a rule that all new equipment purchased be of the permissible type, and this is being done in a few instances.

Miscellaneous recommendations.- Fourteen additional recommendations were made, but these are covered in a general way by the recommendations that have already been discussed.

FATALITIES AND MINE EXPLOSIONS

Table 8 shows the number of explosions and of fatalities for various periods from 1883 to 1932; it will be seen that the period from 1910 to 1919 marks the high point both in the number of explosions and in the number of fatalities; this is also the period of the most active development of the coal industry in Illinois.

TABLE 8.- Number of explosions and fatalities from Explosions in Illinois Mines 1883 to 1932

Years	Explosions	Fatalities	Years	Explosions	Fatalities
1883-1889[1]	1	10	1910-1919	23	176
1890-1899	1	4	1920-1929	14	110
1900-1909	15	138	1930-1932[2]	3	59

[1] 7 years. [2] 3 years

The United States Bureau of Mines, though its Mine Safety Board, issues "decisions" on safety methods and practices. Such decisions as relate to explosion-prevention methods are as follows:

Decision 1:

The United States Bureau of Mines recommends:

1. In all coal mines the portable lamps for illumination be permissible, portable, electric mine lamps; and also
2. In places where fire damp or black damp is liable to be encountered, a permissible magnetically-locked flame safety lamp for gas detection, or equivalent permissible device, be supplied to at least one experienced employee in each such place; and

3. Any employee before being supplied with a permissible flame safety lamp be examined by a competent official of the mine to assure the man's ability to detect gas; and

4. All coal mines whether classed as nongassy or gassy in any part, be supplied with magnetically locked, permissible, flame safety lamps, properly maintained and in sufficient number for all inspection purposes.

Decision 2:

In the interests of safety the United States Bureau of Mines recommends that for blasting in coal mines, permissible explosives, fired electrically, be exclusively used; and that as an aid to blasting, all coal which is feasible to cut, should be cut or sheared.

Decision 4:

In the interest of safety, the United States Bureau of Mines, recommends that auxiliary fans or blowers should not be used in coal mines as a substitute for methods of regular and continuous coursing of the air to every face of the mine.

Decision 5:

To prevent the propagation of mine explosion, the United States Bureau of Mines recommends rock-dusting all coal mines, except anthracite mines, in every part, whether in damp or dry condition. It also recommends that rock-dust barriers be used to sectionalize the mine as additional defense; but these should not be regarded as a substitute for generalized rock-dusting.

Decision 6:

In the interest of safety, the United States Bureau of Mines recommends that in coal mines all entries, rooms, panels, or sections that cannot be kept well ventilated throughout or cannot be inspected regularly and thoroughly, or that are not being used for coursing the air, travel, haulage, or the extraction of coal, be sealed by strong fireproof stoppings.

Decision 7:

In the interest of safety, the United States Bureau of Mines recommends:

1. That the main intake and main return air currents in mines be in separate shafts, slopes, or drifts.

2. That the main intake shaft lining be of fireproof construction, and there be a minimum amount of inflammable material in or adjacent to the shaft.

Decision 9:

The United States Bureau of Mines recommends in coal-mine ventilation practice the following specifications as to unit quantity and quality of air:

1. The quantity in cubic feet of pure intake air flowing per minute in any ventilating split shall be at least equal to 100 times the number of men in that split.

2. The quantity of air entering each unsealed place shall be at least 200 cubic feet per minute and as much more as may be necessary to properly dilute and carry away inflammable or harmful gases which may be present.

3. The air shall be made to circulate continuously to the face in every unsealed place into which an appreciable amount of methane enters.

4. The air in any unsealed place shall be considered unfit for men if it shall be found to contain less than 19 percent oxygen (dry basis), more than 1 percent carbon dioxide or a harmful amount of poisonous gas.

5. If the air in any unsealed place, when sampled or tested in any part of that place not nearer than 4 feet from the face and 10 inches from the roof, shall be found to contain:

(a) more than 1½ percent of inflammable gas, the place shall be considered to be in hazardous condition and require improved ventilation, and

(b) if more than 2½ percent of inflammable gas is found, the place shall be considered dangerous, and only men who have been officially designated to improve the ventilation and are properly protected shall remain in or enter said place.

6. If the air in the split which ventilates any group of workings contains more than 1½ percent of inflammable gas, these workings shall be considered to be in a dangerous condition and only men who have been officially designated to improve the ventilation and are properly protected, shall remain in or enter said workings.

Decision 11:

In the interest of safety, the United States Bureau of Mines recommends that in coal mines, haulage and (or) hoisting be kept in intake air as far as possible.

Decision 12:

The United States Bureau of Mines extending Mine Safety Decision No. 2, recommends that for blasting either coal or rock in coal mines, permissible explosives or equivalent permissible device be used exclusively, and in addition, recommends that in blasting--

1. Each charge shall be in a hole properly drilled and stemmed with incombustible material.

2. Each shot shall be fired separately by a permissible single-shot blasting unit, using an electric detonator or igniting equivalent of a kind specified by the bureau for the particular permissible explosive or permissible blasting device.

3. Before and following each shot in gassy and slightly gassy coal mines, examination for gas shall be made with a permissible flame safety lamp or permissible equivalent and--

4. If more than $1\frac{1}{2}$ percent of inflammable gas is found, in the quantity and by the method specified in Mine Safety Decision No. 9, the place shall be considered to be in a hazardous condition and before another shot is fired the gas shall be reduced by ventilation below the percentage and quantity specified in decision 9.

5. Each shot employing explosives shall be prepared and fired by or under the immediate supervision of a man having a state certificate as a mine examiner, fire boss, or foreman; and whenever conditions permit all other men than those authorized to prepare and fire shots shall be out of the mine when shot firing with explosives is being done.

Decision 13:

The United States Bureau of Mines recommends that when electricity is used in coal mines rated as gassy, or wherever in any mine the atmosphere may become gassy:

1. Electrical equipment shall be permissible.
2. Nonpermissible electrical equipment shall be used only in pure intake air.
3. Electrical power shall be cut off whenever the air in the workings is in a dangerous condition, due to inflammable gas.

Decision 15:

In the interest of safety in coal mining, the United States Bureau of Mines to lessen the coal-dust explosion hazard recommends that:

1. Machine coal cuttings be wet as the cutting is being done.
2. The coal face, and the working place 40 feet therefrom, shall be kept free of coal-dust by the use of water.
3. The top of loaded cars in the working place shall be wet.

Decision 16:

In the interest of safety in coal mining, the United States Bureau of Mines recommends that:

1. Machine cuttings be removed from the cut.
2. If the machine cuttings are of a character which would contribute to a dust explosion, they shall be sent out of the mine.

Decision 17:

To lessen the formation and distribution of coal dust in haulage-ways, the United States Bureau of Mines recommends that in bituminous and lignite coal mines:

1. The mine cars should be constructed and maintained dust-tight.
2. The coal should be so loaded that it will not shake off in haulage.
3. The cars and loads should be so sprayed as to prevent dust being distributed along the haulage ways.

Decision 18:

In the interest of safety in coal mining, the United States Bureau of Mines recommends that:

1. The foreman regularly in charge of underground operations and also any person who, in the absence of the foreman, may be placed in temporary charge should each have a certificate of competency from the State to act as mine foreman.

2. The superintendent or person in responsible charge of the mine, to whom the mine foreman reports, should have a certificate of competency from the State which should be issued upon a showing of underground experience for a period of time as long as that required for a foreman's certificate and upon passing an examination including all technical questions asked in the examination required of foremen.

3. These certificates should expire after some stated period of time, such as 5 years, and should be renewed only after the applicant has again passed the examination required by the State.

Decision 20:

In the interest of safety in underground mining, the United States Bureau of Mines recommends that:

While driving tunnels or drifts and sinking or raising shafts or slopes, and also in their operation, there should be an adequate ventilating current wherever men work or travel.

CONCLUSIONS

The principal underlying causes of mine explosions in Illinois have been insufficient or interrupted ventilation and the reckless use of black blasting powder. The chief causes of ignitions of gas or dust were open lights, blown-out shots of black blasting powder, mine fires, electricity, explosives, and striking matches.

Explosion prevention depends largely upon adequate ventilation and inspection, thorough rock-dusting, the moistening of coal dust at the face to prevent its dissemination throughout the mine, the use of permissible explosives and equipment, and last but by no means least, proper supervision to insure that the foregoing fundamental requirements are kept in effect.

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